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ABSTRACT

This document describes an aid invented by the author for teaching binary computer concepts in a data processing course for business students unfamiliar with mathematical concepts. It permits the instructor to simulate the inner, invisible operation of storing data electronically. The standard 8-bit "byte" is represented by a portable "light-board" containing eight small light bulbs, each equipped with a switch for independent operation. With all bulbs off, the board corresponds instructionally to a bit configuration for a computer card column. A 1-punch can then be represented by switching on the right-most bulb and affixing a label containing the digit '1' to the bulb. The instructor can then explain that this bulb has been used in both its states (on/off). Instruction proceeds by repeating this process with other bulbs. The device can also be used to demonstrate Hollerith and other coding systems. Complete schematics for building the unit are appended. (Author/RT)

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A NON-MATHEMATICAL TECHNIQUE FOR TEACHING BINARY COMPUTER CONCEPTS

JC 770 436

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A NON-MATHEMATICAL TECHNIQUE FOR TEACHING BINARY COMPUTER CONCEPTS

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In teaching introductory courses in business-oriented Data Processing, the author has frequently found that the conventional "powers of two" approach produces more confusion than enlightenment among students. One source of the problem apparently lies in the fact that students enrolled in business-oriented curricula may be less familiar with mathematical concepts than are those in science-oriented curricula. Yet the concepts of binary eletronic storage are vitally important to meaningful insights as to the nature of computerized data processing. The indicated solution was to develop a non-mathematical technique in which the student could discover for himself the binary concepts involved. In pursuing this course, the author developed an instructional technique, aided by a homemade visual device, that seeks to relate the binary representation of data in a computer's CPU to a more commonplace binary event, namely, the flipping of a light switch.

The visual device is portable, and is powered by an ordinary 6-volt dry cell battery. It is built of commonplace components, using commonplace tools and commonplace skills. It permits the instructor to simulate, overtly and visibly, the inner and invisible operation of storing data electronicly in a computer's CPU. Thus the standard 8-bit "byte" of conventional computer architecture is represented by a "light-board" containing eight small light bulbs similar to those used in an ordinary flashlight. Each bulb is equipped with its own switch, permitting it to be turned on or off independently of the other bulbs in the light-board. Thus the two-state electronic bit can be related to the visible two-state bulb, and abstract "powers of two" concepts can be replaced by a visual, concrete, familiar occurrence. A bill of materials for building the device is included in the Appendices, along with diagrams and directions for assembling and wiring the device.

In the classroom, of course, the use of this device requires an instructional technique that also avoids abstract mathematical concepts. The technique evolved by the author begins with an explanation of the computer's input function as a means of making external data available to the CPU for subsequent internal processing. This phase is followed by a demonstration of the Hollerith codes that are used to represent numeric values in an 80-column punched card. A handout of such cards, punched in successive columns with the ten numeric codes, has proven effective for this demonstration.

The next step is to relate the punched card to the light-board. With all of its bulbs turned off, the light board corresponds instructionally to a bit configuration for an unpunched column in the card. Then the bit configuration for a column containing a 1-punch can be represented on the light-board by flipping the switch for the rightmost bulb, and affixing a label containing the digit "1" to the bulb. The instructor can now point out that this rightmost bulb has been used in both of its possible states, and that further representation will require using additional bulbs. He can further explain that as each new bulb is introduced, the label affixed to it will contain the number that occasioned its use. Thus, when the next bulb is switched on it will receive a label containing the digit "2", representing a 2-punch in the card. A 3-punch, of course, can be represented by lighting both bulbs, but a 4-punch requires employing still another new bulb. In such manner, the binary values of 4-bit BCD coding in the CPU can be related to the decimal structure of Hollerith coding, and the students can observe for themselves that the values on the labels double in size with each new bulb that is used.

At this point, the author has found it effective to introduce, by handout, the 96-column punched card. The identity between the numeric row values on the card and the label values on the light-board is readily apparent and leads inevitably to a question from the class about the "B" and "A" rows on the card. In response, the instructor can explain the zone-and-digit coding scheme for alphameric characters in the 6-bit BCD code. The transition to the light-board can then be effected by utilizing two more bulbs, for a total of six. Finally, the structure of the 8-bit EBCDIC and ASCII coding systems can be demonstrated by using all eight bulbs on the light-board, and affixing appropriate labels to them.

Now the transition from the "on's" and "off's" of the light-board to the written binary digits "1" and "0" becomes virtually painless for the student. Thus the written binary notation loses its mystery and becomes a familiar process. The students' comprehension of subsequent blackboard exercises in binary arithmetic will no longer be clouded by unfamiliar concepts and notation.

During several semesters of use, the light-board approach has received favorable comments from students and from auditing faculty. More significantly, the students' performance in class discussion and on test questions involving binary concepts has indicated an encouraging level of comprehension.

APPENDIX "A"

An overview of the light-board's construction

Appendix "B" shows the student's view of the light-board. Appendices "C", "D" and "E" show, respectively, the side-, top- and rear-views.

The body consists of a 16" x 11" piece of 3/16" plywood, affixed to a base that holds it upright. The author found that an ordinary wooden miter-box of sufficient length served ideally as a base, with the lower edge of the plywood panel resting on the outside lip of the miter-box. Three flat-head screws (½") secure the panel to the box if they are countersunk.

Sixteen holes are drilled in the panel to accommodate the eight bulb sockets and their corresponding switches. The forward surface of the panel is faced with black construction paper to provide maximum contrast with the lighted bulbs. About one inch below each switch hole, a 3/4" x 1/2" strip of self-adhering plastic magnetic tape is affixed to the construction paper. Such tape is readily available in hobby shops. Centered below the rightmost four socket holes is a 2½" x½" strip of magnetic tape. An identical strip is centered below the leftmost four socket holes. These long strips of magnetic tape will accommodate labels reading ZONE and DIGIT; the eight short strips will accommodate value labels for their corresponding bulbs.

Between the two center socket holes is a vertical strip of magnetic tape 5" x ½" to accommodate a vertical line separating the ZONE bulbs from the DIGIT bulbs when alphameric codings are being represented. This line can be made by cutting a ½" strip from an 80-column card and affixing it, blank side out, to magnetic tape of similar length.

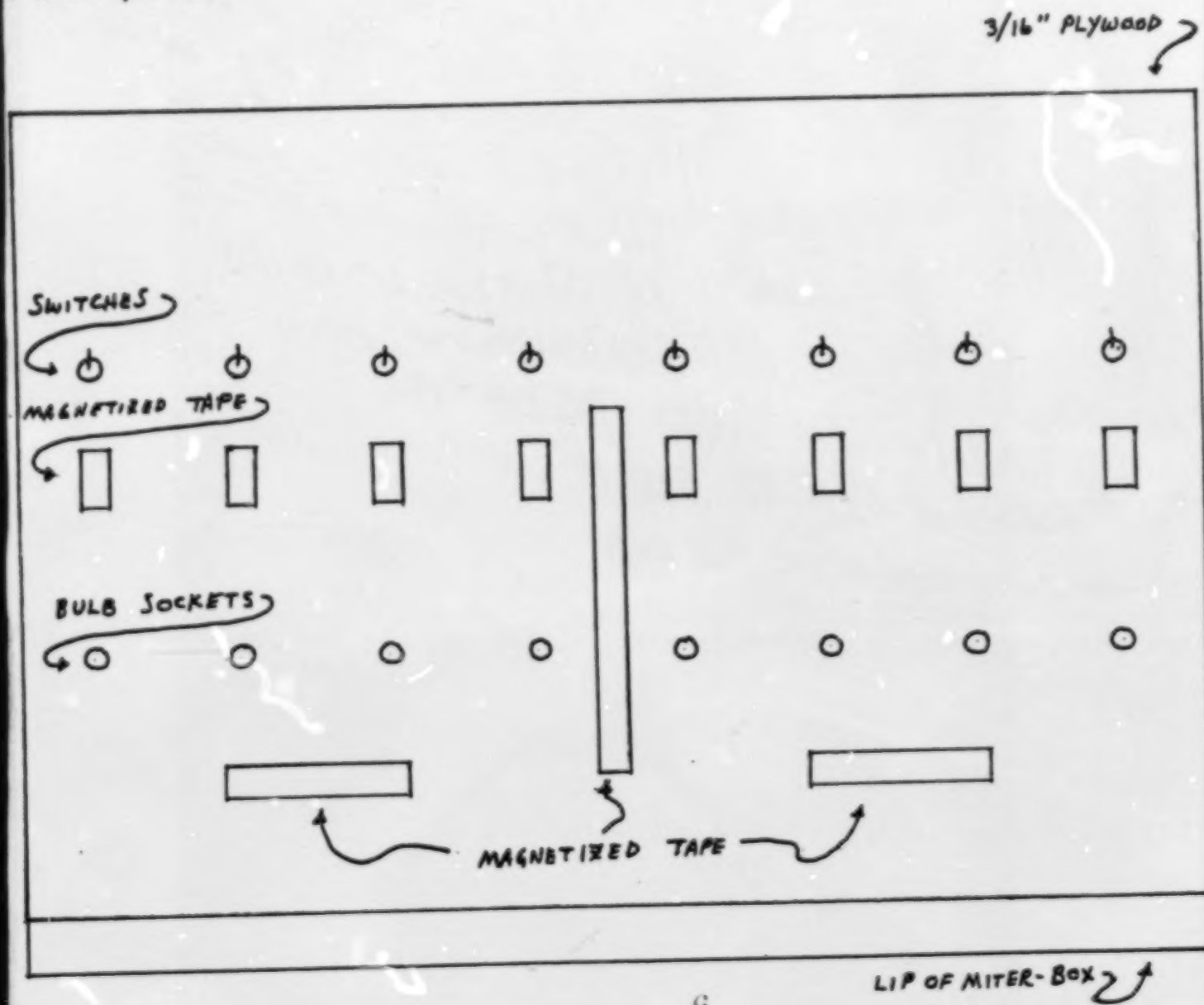
The labels containing the binary values (1,2,4,8), the BCD zone letters (A,B) and the words ZONE and DIGIT, consist of 1" CHARTPAK characters, which can be purchased in shops that carry drafting supplies. The Chartpak letters are white, and are affixed to rectangles of black construction paper. For the digits and letters, the rectangles measure 1½" x 3"; for ZONE and DIGIT they measure 1½" x 4".

The 6-volt dry cell battery that powers the device will fit snugly inside the miter-box, if desired, or can stand free as well. The switches and sockets are wired in series on the device built by the author, but parallel wiring may be suitable or even better. When the device is not in use, the battery leads are disconnected, and the bulbs are stored in the original container. Setup time for classroom use is about five minutes.

APPENDIX "B"

FRONT VIEW OF LIGHT-BOARD

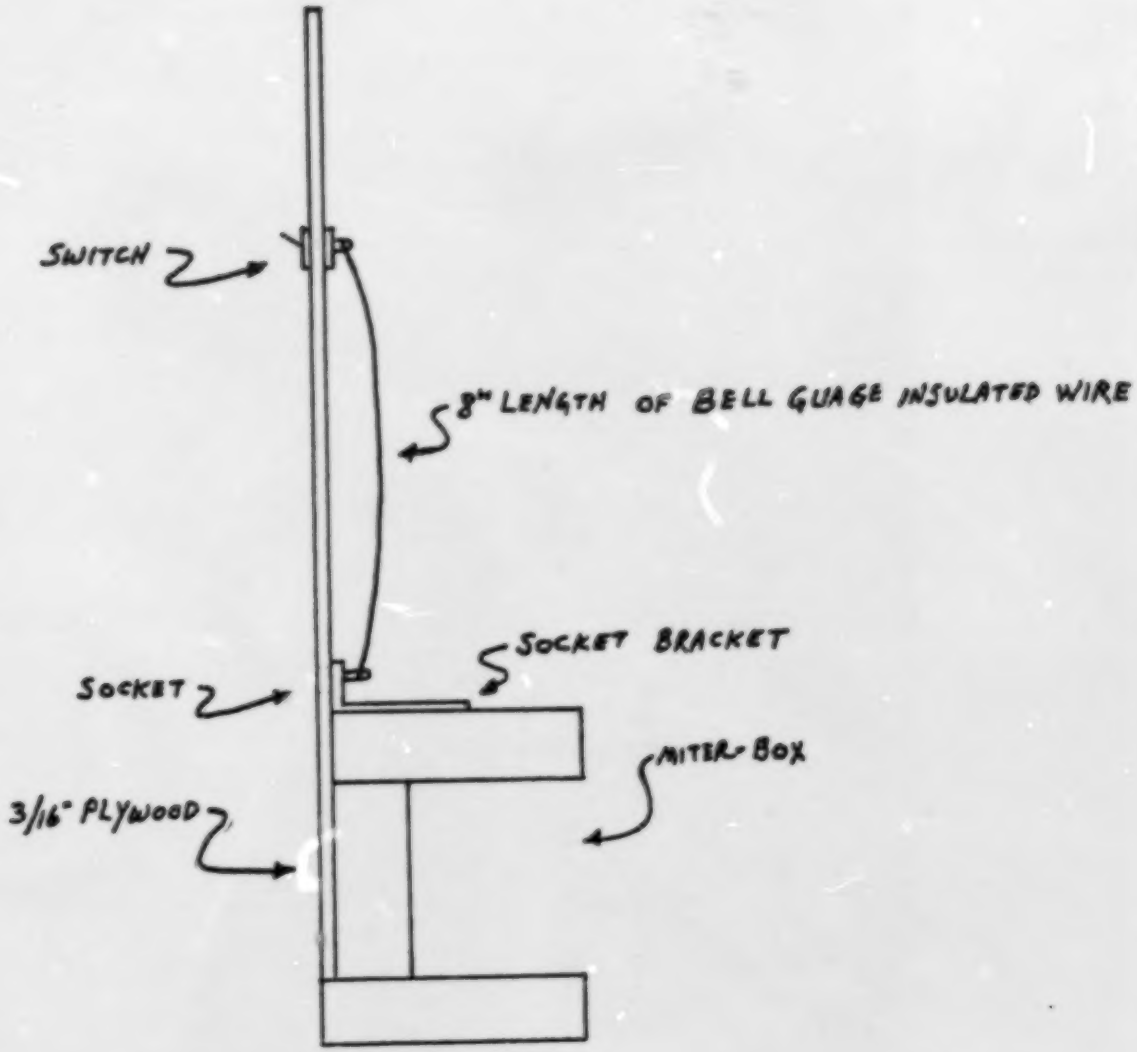
SCALE: 1/2" = 1"



APPENDIX "C"

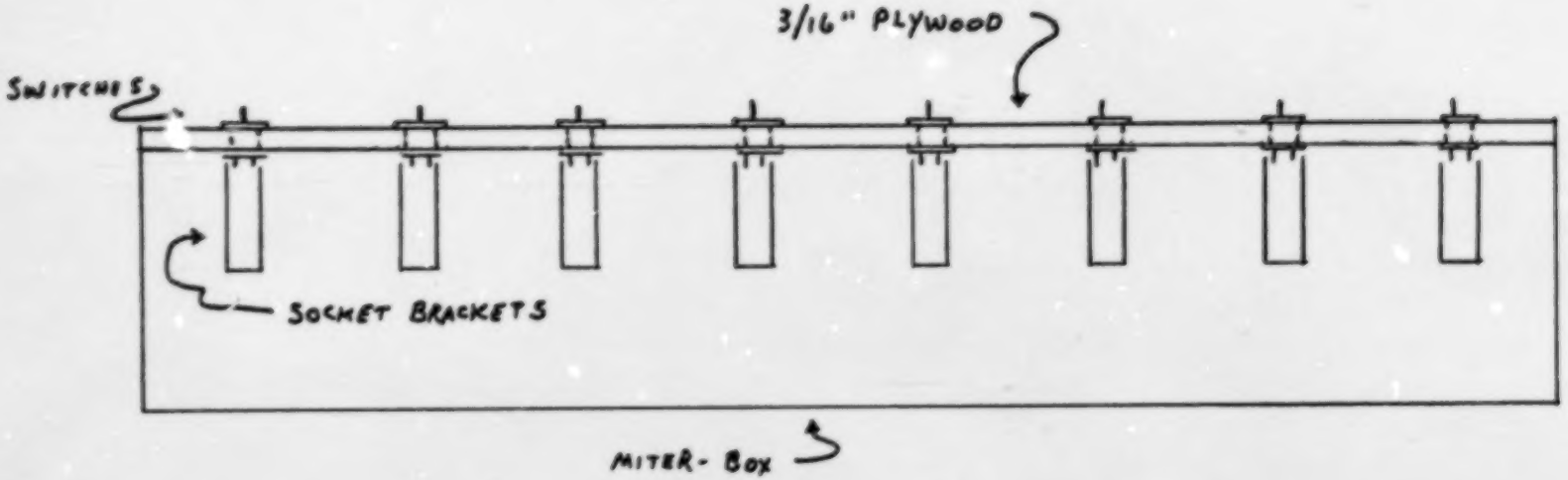
SIDE VIEW OF LIGHT-BOARD

SCALE: 1/2" = 1"



APPENDIX "D" Top VIEW OF LIGHT-BOARD

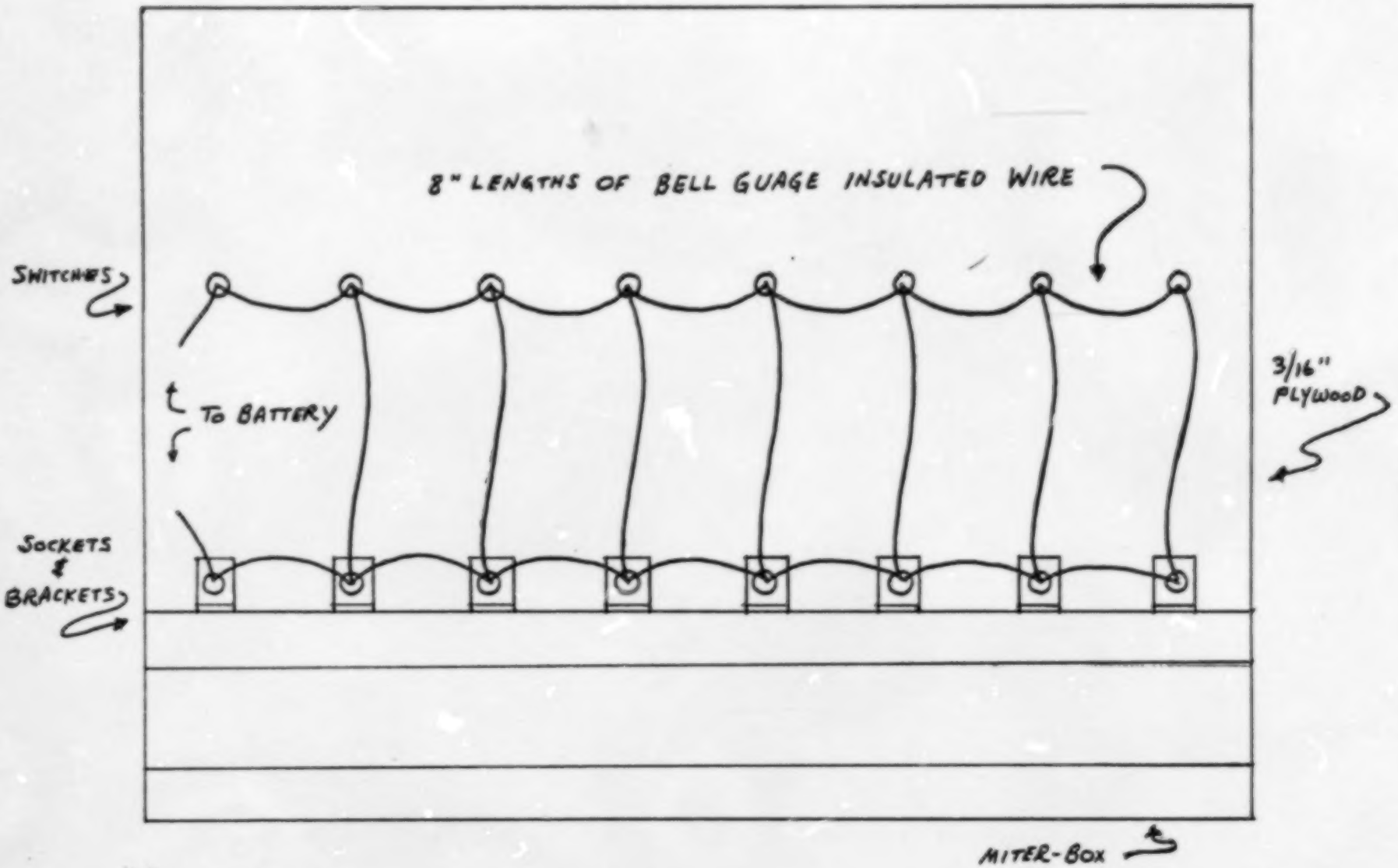
SCALE: 1/2" = 1"



APPENDIX "E"

REAR VIEW OF LIGHT-BOARD

SCALE: 1/2" = 1"



APPENDIX "F"

Bill of Materials

1. Eveready 6-volt dry cell battery, post type, with screw caps (No. 5105 neda 915)
2. 8 lamps, Chicago Miniature Lamp Works #46, with screw type bases
3. 8 lamp sockets, with fastening brackets
4. 8 toggle switches
5. 23 eight-inch lengths of insulated bell guage wire, with open-end terminals for attaching to battery posts, lamps and switches
6. 11" x 16" panel of 3/16" plywood
7. 16" wooden miter-box
8. 4 sheets of 8½" x 11" black construction paper
9. CHARTPAK characters (1"), white, per Appendix "A"
10. Roll of self-adhering plasticized magnetic tape
11. 3 flathead wood screws (½") for securing panel to miter-box
12. 16 roundhead wood screws (½") for securing socket brackets to miter-box

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